EXPERIMENTS WITH WINTER WHEAT.

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BULLETIN

OF THE

Ohio Agricultural Experiment Station

NUMBER 165. AUGUST, 1905.

EXPERIMENTS WITH WINTER WHEAT.

BY C. G. WILLIAMS.

It is the purpose of this bulletin to report experiments with a number of different varieties of winter wheat, grown at this station during the last thirteen years, giving attention to comparative yield in bushels per acre; grade or quality of grain as shown by weight per bushel; resistance to rust; per cent of protein and the factors having a bearing upon protein content; milling and baking quality, the scoring of varieties; cultural work in thick and thin, and early and late seeding; and methods of improving the yield and quality of our best varieties of wheat by selection.

THE FIELD TEST.

The Station devotes a range of 90 tenth-acre plots each season to a comparative test of varieties of wheat, which are grown in a four-year rotation of corn, oats, wheat and clover. A little timothy is seeded with the clover in the spring.

Thirty plots—every third plot—are given to a check variety, leaving sixty plots for the different varieties. This seemingly large number of check plots is found essential to accurate work. Experience has shown that a comparison of varieties with each other is of very little value.

We find variations of yield in our thirty check plots, scattered through the ninety plots of apparently very even soil, which will account for wide differences in yield of varieties.

The check plot is used as a sort of yard stick placed beside each variety tested, by means of which the variety is measured. The same variety has been used in this work from the start, namely, Penquite's Velvet Chaff.

DESCRIPTION OF VARIETIES.

In Table I is given the average height in inches of the varieties grown the past two seasons; whether bearded or smooth; color of grain and chaff and number of kernels per head and per ounce.

TABLE I.—A COMPARATIVE DESCRIPTION OF VARIETIES.

VARIETY.	Height of plants, inches.	Bearded or smooth.	Color.		Number of kernels.	
			Grain.	Chaff.	Head.	Ounce.
American Bronze	48	Smooth	Red	White	35	814
Bearded Winter Fife	47	Bearded	White	White	37	766
Buda Pesth	49	Bearded	Red	White	33	808
Currell's Prolific	51	Smooth	Red	Red	40	848
Dawson's Golden Chaff	47	Smooth	White	Red	38	786
Diamond Grit	47	Bearded	Red	White	48	924
Deitz	45	Bearded	Red	White	33	758
Democrat	47	Bearded	White	White	35	814
Early Red Chief	50	Smooth	Red	Red	37	692
Early Red Clawson	53	Smooth	Red	Red	30	796
Early Ontario	45	Smooth	Red	White	40	782
Early Ripe	51	Smooth	Red	Red	43	828
Extra Early Windsor	46	Smooth	White	Red	38	736
Economy	46	Smooth	Red	White	38	898
Farmers' Friend	51	Bearded	Red	White	24	634
Farmers' Trust	48	Bearded	Red	Red	39	850
Fulcaster	48	Bearded	Red	White	37	742
Fultz	47	Smooth	Red	White	36	874
Fultzo-Mediterranean	45	Smooth	Red	White	41	786
Giant SquareHead	44	Bearded	White	Red	39	810
Gold Coin	45	Smooth	White	Red	40	804
Golden Bronze	45	Smooth	White	Red	39	828
Grains o' Gold	40	Bearded	Red	White	31	1114
Gypsy	49	Bearded	Red	White	41	866
Harvest King	47	Smooth	Red	Red	33	852
Harvest Queen	48	Smooth	White	White	48	810
Hickman	45	Smooth	Red	White	27	844
International No. 6	45	Smooth	White	Red	36	832
Invincible	47	Smooth	Red	White	39	798
Jones' Longberry No. 1	49	Bearded	White	Red	40	746
Jones' Square Head	49	Smooth	White	White	44	822
Lebanon	48	Bearded	Red	White	33	718
Lehigh	49	Bearded	Red	Red	27	792
Mealy	49	Smooth	Red	White	47	1016
Mediterranean	48	Bearded	Red	Red	32	812
Mortgage Lifter	47	Smooth	Red	Red	36	894
New American Banner	47	Smooth	White	Red	42	750
New Monarch	55	Smooth	Red	White	38	834
Nigger	46	Bearded	Red	White	24	754
Nixon	47	Smooth	Red	White	31	882
No. 8	47	Smooth	Red	White	42	784
Oatka Chief	48	Bearded	Red	White	48	894
Perfection	45	Smooth	Red	Red	34	854
Poole	48	Smooth	Red	Red	36	824
Pride of Genesee	49	Bearded	Red	White	42	822
Prosperity	49	Smooth	Red	White	45	798
Red Cross	47	Smooth	Red	Red	35	728
Red Wonder	47	Bearded	Red	White	34	698
Rural New Yorker No. 6	48	Smooth	Red	Red	40	808
Satisfaction	47	Smooth	White	White	45	776
Shepard's Prolific	49	Bearded	Red	Red	41	712
Sibley's New Golden	49	Bearded	Red	Red	27	770
Silver Sheaf Longberry	51	Bearded	Red	White	44	798
Smith's Rust Proof	51	Smooth	White	White	31	876
Stanley	48	Bearded	White	White	44	998
Turkish Red	40	Bearded	Red	White	33	1046
Valley	49	Bearded	Red	White	34	830
Velvet Chaff	47	Bearded	Red	Red	36	864

Table II gives a list of varieties which have been tested from 6 to 12 years; the average increase or decrease in bushels per acre as compared with the check variety; the per cent of rust

resistance; average date of ripening; the weight per bushel before screening, and the rank in yield. The rating upon rust resistance is for the harvests of 1904 and 1905 and was made by Mr. J. M. Van Hook, assistant plant pathologist of the Station. In 1904 rust was quite prevalent. In 1905 but little damage was experienced.

TABLE II.—COMPARATIVE YIELD, AVERAGE WEIGHT PER BUSHEL, RUST RESISTANCE AND AVERAGE DATE OF RIPENING FOR A SERIES OF YEARS.

VARIETY.	Av. increase + decrease — for 6 to 12 years.		Rank in yield.	Average weight per bushel before screening.	Per cent. rust resistance.	Average date of ripening.
	yrs.	bus				
American Bronze	12	+0.15	31	56.71	80	July 8
Bearded Winter Fife	7	+0.45	24	56.85	85	" 6
Bearded Monarch	11	+0 17	30	58.17		" 6
Currell's Prolific	12	+2.11	9	58.82	75	" 7
Dawson's Golden Chaff	7	+1.71	10	56.74	80	" 6
Diamond Grit	7	−1.36	45	57.92	72	" 7
Deitz	12	+0.83	17	58.85	87	" 7
Democrat	12	+1.57	12	58.64	90	" 7
Early Arcadian	7	−3.01	50	55.37		" 8
Early Genesee Giant	10	−1.03	42	57.00		" 8
Early Red Clawson	12	−0.66	40	57.49	72	" 7
Early Ripe	12	+3.41	3	58.25	82	" 7
Forty Fold	8	−0.54	39	55.46		" 8
Fulcaster	12	+0.79	18	59.17	85	" 7
Fultz	12	+0.42	25	58.39	79	" 6
Fultzo-Mediterranean	6	−0.83	41	57.70	75	" 6
Giant Square Head	7	+0.06	32	53.68	80	" 9
Gold Coin	10	−0.31	37	55.60	80	" 7
Gypsy	12	+3.79	1	59.10	85	" 6
Harvest King	7	+1.69	11	57.79	79	" 6
Harvest Queen	6	+0.67	21	55.74	75	" 7
Hickman	12	+0.29	28	59.29	82	" 6
International No. 6	9	+0.91	16	55.18	77	" 6
Jones' Longberry No. 1	6	+0.76	19	57.17	81	" 8
Jones' Square Head	12	−1.52	46	55.78	77	" 8
Jones' Winter Fife	11	−2.02	48	55.88		" 7
Lebanon	12	+0.74	20	58.67	81	" 7
Lehigh	12	+0.47	23	58.32	80	" 7
Long Amber	10	−1.56	47	57.13		" 7
Mealy	12	+3.69	2	56.25	80	" 6
Mediterranean	12	+2.22	7	58.32	86	" 7
New Columbia	11	−0.23	34	56.71		" 5
New Monarch	12	+1.49	13	57.50	80	" 7
New Soules	8	+0.62	22	54.58		" 8
Nigger	12	+3.11	5	58 68	92	" 6
Nixon	7	+1.44	14	58.66	77	" 6
Perfection	10	+2.34	6	58.79	82	" 5
Poole	12	+3.17	4	57.80	84	" 6
Pride of Genesee	10	−1.25	44	57.74	79	" 7
Red Cross	7	−0.34	38	56.91	82	" 6
Red Wonder	7	+1.26	15	59.28	85	" 6
Rochester Red	10	−1.10	43	57.68		" 7
Rural New Yorker No. 6	6	+0.35	27	55.17	80	" 9
Sibley's New Golden	12	+0.20	29	58.17	87	" 7
Smith's Rust Proof	10	+0 42	26	56.75	85	" 9
Stanley	7	−0.27	35	56.53	85	" 8
Turkish Red	6	−2.11	49	57.29	95	" 10
Valley	12	+2.15	8	58.87	85	" 7
Velvet Chaff *	12	....	33	58.20	76	" 6
White Golden Cross	9	−0.30	36	56.29		" 7

*Average yield of Velvet Chaff for 12 years, 20.65 bushels per acre.

The table is self explanatory and comment upon the different varieties at this time is unnecessary.

Barly Ripe. Perfection. Currell's Prolific. Poole.

Early Red Chief. Dawson's Golden Chaff. Harvest King. Extra Early Windsor.

THE PROTEIN CONTENT OF WHEAT.

There are several qualities which a wheat must have to commend it to the miller and baker. Not the least of these is high protein content.

As Dr. Wiley, Chief of the Bureau of Chemistry of the United States Department of Agriculture, has pointed out: "It is generally conceded that the value of a wheat for milling and bread-making purposes depends more largely upon its nitrogen content than any other."* Prof. Harry Snyder, chemist of the Minnesota Experiment Station, says: "As a general rule, wheats which contain the largest amount of nitrogen produce the most nitrogenous flours, but the total nitrogen in the wheat cannot always be taken as an index of that in the flour."**

The exceptions to this general rule as stated by Prof. Snyder are due to relatively larger proportions of bran, aleurone layer and germ, as compared with endosperm.

While "bushels per acre" rightly commands the first attention of the wheat grower and failure to produce satisfactorily cannot be atoned for by quality of product, yet quality of product must be closely associated with yield. The object for which wheat is grown must not be lost sight of. Sooner or later the high yielding variety of wheat without quality will make way for the high yielding variety with quality.

The writer is indebted to the chemist of this Station, Prof. John W. Ames, for nitrogen determinations of 43 different varieties of wheat grown at the Station for the past four years. It has been thought best to omit from the following table the few varieties for which the record is not complete.

For the purpose of studying the relation of yield and weight per bushel to per cent of protein (nitrogen x 6.25) Table III includes the comparative yield of these varieties and their weight per bushel before screening. The above facts are given for each of the four years and for the average of the four years. The total weight of protein per acre is computed for each variety.

In the last four columns will be found the comparative rank in yield of grain, pounds of protein, per cent of protein and weight per bushel. All save the yield of grain is based upon the data included in the table. The latter is based upon the longer test. (See Table II.)

*Year book Dpt. of Agriculture 1901, page 305.

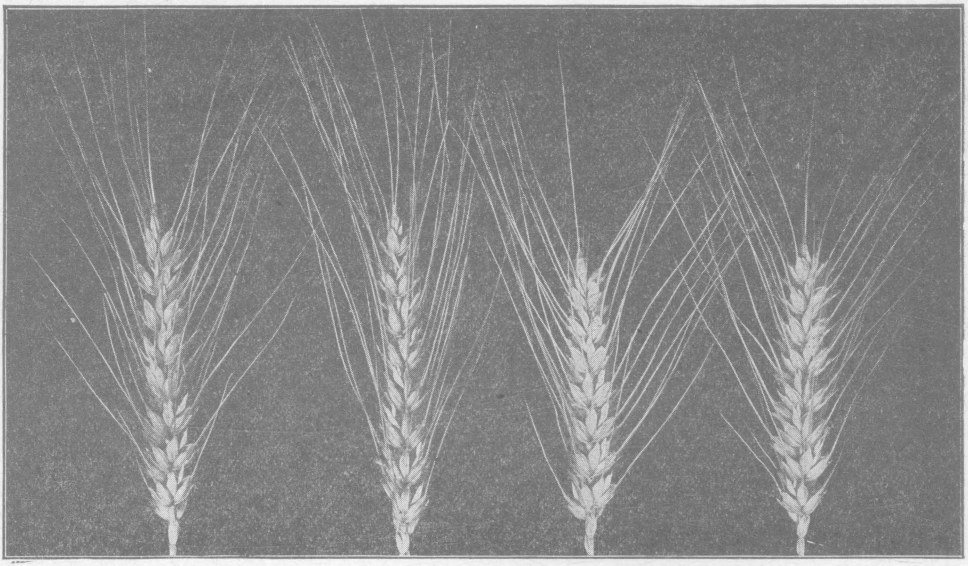
**Chemistry of Plant and Animal Life, page 278.

TABLE III.—THE PROTEIN CONTENT OF WHEAT.

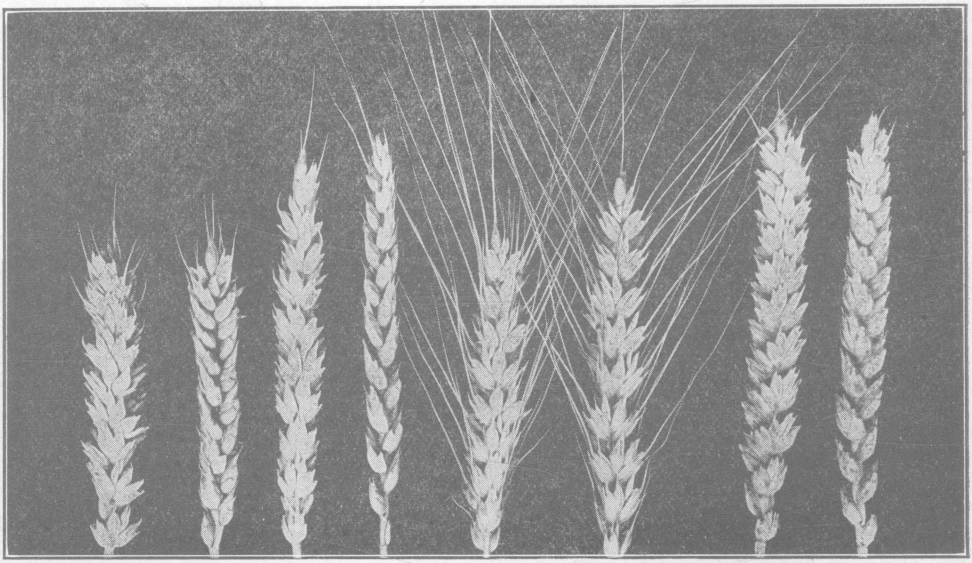
NAME OF VARIETY.	1904			1903			1902			1901			Average.			Pounds protein per acre.	Rank.			
	Increase + Decrease —	Per cent protein.	W't per bus.	Increase + Decrease —	Per cent protein.	W't per bus.	Increase + Decrease —	Per cent. protein.	W't per bus.	Increase + Decrease —	Per cent protein.	W't per bus.	Increase + Decrease —	Per cent protein.	W't per bus.		Yield 12 yr. test.	P'nds protein. per acre.	Per cent protein.	W't per bus.
	Bus.		Lbs.	Bus.		Lbs.	Bus.		Lbs.	Bus.		Lbs.	Bus.		Lbs.		No.	No.	No.	No.
American Bronze	—0.46	12.50	55.00	—3.42	9.17	58.75	+2.17	11.94	57.00	+0.17	15.38	53 50	—0.34	12.25	56.06	174.42	26	37	34	36
Bearded Winter Fife	+2.22	12.81	55.25	+1.30	9.34	58.75	+2.83	11.46	57.25	+0 17	14.95	55.20	+1.63	12.09	56.61	186.43	20	29	38	31
Buda Pesth	+2.57	14.38	67.00	—1.72	9.68	60.25	+2.75	12.46	59.25	+3 76	17.22	58.00	+1.84	13.44	58.62	208.94		13	10	11
Currell's Prolific	+0.12	13.75	58.25	+4.23	9.43	60.50	+2.13	12.67	58.00	+2.29	17.09	57.00	+2.19	13 24	58.44	208.61	7	15	14	13
Dawson's Golden Chaff	+3.72	12.25	55.75	+2.67	8.57	58.50	+0.75	11.37	57.25	+1 50	14.15	53.70	+2.16	11 58	56.30	182.25	8	34	43	35
Diamond Grit	—0.87	12.19	56.75	—1.92	9.50	60.75	+1.05	11.65	57.50	+0.25	14.47	55.00	—0.37	11.95	57.50	169.93	35	40	40	22
Deitz	+0.90	13.63	58.50	+3.89	10.18	60.75	+4.42	13.18	59.50	+2.67	17.37	58.20	+2.97	13.59	59 24	220.48	15	3	9	3
Democrat	+4.59	13.31	58.75	+3.03	9.88	60.50	+2.84	13.58	58.25	+4.21	16 34	56.50	+3.67	13.28	58.50	221.03	10	2	12	12
Early Arcadian	—3.70	13.06	53.00	+0.78	9.00	56.75	—4.12	11.84	57.25	—3.42	14.72	52.70	—2.61	12.16	54.92	156.57	39	43	35	41
Early Red Clawson	+4.59	13.75	59.00	—2.86	9.34	58.00	—2.04	12.49	57.75	+0.51	15.53	54.70	+0.05	12.78	57 36	184.95	40	30	27	24
Early Ripe	+4 56	14 00	59 25	+1.00	9.76	59.25	—0.79	12.56	58.75	+4.50	16.41	55.00	+2.32	13.18	58.06	208.69	3	14	15	18
Economy	+0.55	14.25	58.50	+5.18	9.09	60.50	+0.67	13.15	58.25	—0.24	15.87	58 00	+1.54	13.09	58.81	201.14		18	18	7
Fulcaster	+3 05	14.38	58.00	+3.19	10.09	61.75	+3.80	13.29	59.25	+1.88	17.67	56.70	+2.98	13.86	58.92	224.95	16	1	5	6
Fultz	—1.34	11.19	58 50	+3 91	9.51	61.00	+1.17	13.17	57.00	—0.08	16.56	56.70	+0 92	13.36	58.30	200.42	21	19	11	15
Fultzo-Mediterranean	—3 42	14.06	57 50	+3.70	9.34	60.25	+1.66	13.64	58.50	—3.62	17.37	55 20	—0.42	13.60	57.86	192.98	33	25	8	19
Giant Square Head	—0.41	13.63	51.75	—0.22	9.50	58 75	—1.24	13.00	55.50	—0.91	16.31	45.20	—0.70	13.11	52.80	183.83	27	31	17	43
Gold Coin	+3.09	12.31	55.50	+0.25	9.17	58.00	—2.45	11.98	56.50	—1.50	14.78	52.20	—0.15	12.06	55.55	173.09	31	38	39	38
Gypsy	+6 52	12.88	59.00	+1.50	9.17	60.25	+4.46	12.60	58.75	+7 08	14.91	57.20	+4.89	12.39	58.80	215.32	1	7	33	8
Harvest King	+2.34	13.19	58.25	+1.70	9.34	59.50	+0.42	11.93	57.25	+4.67	16.22	56.00	+2.28	12.67	57.75	200.31	9	20	30	21
Harvest Queen	+2.29	12.44	55.00	—0.53	9.17	57.00	—1.66	11.65	55.75	+4.47	14.22	58 20	+1.14	11.87	56 49	179.55	18	36	41	33
Hickman	+2.78	14.50	59.00	+2.41	9.76	60.50	—1.49	12.21	59.50	+3.83	16.56	58.00	+1 88	13.26	59 25	206.46	24	16	13	2
International No. 6	+3.23	13.06	56.00	—3.22	9.00	56.75	—2.38	11.82	54.50	+0.92	14.47	49 00	—0.36	12.09	54.06	171.99	14	39	37	42
Jones' Square Head	+3.88	13.50	55.50	+2.84	9.25	58.75	—1.74	12.09	56.75	—1.08	15.84	53.20	+0.98	12.67	56.05	190.43	36	27	29	37
Lebanon	+1.25	13.94	58.00	+1.44	10.01	61.50	+2.84	13.41	60.00	—0.49	17.89	57.70	+1.26	13.81	59.30	209.88	17	12	6	1
Lehigh	+1.23	14.06	57.50	—0.20	10.68	60.50	+2.09	14.24	59.50	+0.25	18.02	58.50	+0.84	14.25	59.00	212.98	19	8	2	4
Long Amber	+1.62	12.06	56.25	+0.75	9.65	59.75	+0.54	11.66	58.50	+0.25	15.09	53.20	+0.79	12.12	56.92	180.78	37	35	36	26

TABLE III. (CONTINUED).—THE PROTEIN CONTENT OF WHEAT.

NAME OF VARIETY.	1904			1903			1902			1901			Average.			Pounds protein per acre.	Rank.			
	Increase + Decrease —	Per cent protein.	W't per bus.	Increase + Decrease —	Per cent protein.	W't per bus.	Increase + Decrease —	Per cent protein.	W't per bus.	Increase + Decrease —	Per cent protein.	W't per bus.	Increase + Decrease —	Per cent protein.	W't per bus.		Yield 12 yr. test.	P'nds protein per acre.	Per cent protein.	W't per bus.
	Bus.		Lbs.	Bus.		Lbs.	Bus.		Lbs.	Bu s.		Lbs.	Bus.		Lbs.	Bus.	No.	No.	No.	No.
Mealy	+2.77	13.81	55.50	+0.28	9.26	58.50	+3.62	12.42	54.25	+1.58	14.91	52.50	+2.06	12.60	55.19	197.54	2	23	31	39
Mortgage Lifter	+2.05	13.50	58.75	+4.59	9.76	59.75	+3.67	13.13	58.75	+4.84	15.59	59.00	+3.79	13.00	56.56	217.31		6	24	32
New Columbia	−3.01	14.25	57.00	+5.08	9.50	59.50	−3.08	13.50	56.50	−4.04	17.28	54.50	−1.26	13.63	56.80	186.54	29	28	7	27
New Monarch	+0.74	13.94	56.00	−1.69	9.84	57.75	+0.17	12.96	55.00	+3.34	15 87	57.00	+0.64	13.15	56.44	194.96	11	24	16	34
Nigger	+7.15	13.50	59.00	+3.22	9.50	60.00	+0.29	12.29	58.25	+5.33	16.94	58.50	+4.00	13.06	58.94	219.96	5	5	21	5
Nixon	+0.15	14.06	57.75	+4.14	9.34	60.50	+0.16	12.31	59.00	+0.91	16.28	55.70	+1.34	13.00	58.24	198.20	12	22	23	16
Poole	+1.44	13.31	58.00	+3 39	9.75	59.25	−0.66	12.39	58.25	+4.50	16,19	57.20	+2.17	12.91	58.17	203 26	4	17	25	17
Pride of Genesee	+0 87	12.31	56.50	−3.59	9.17	59.50	−0.04	10.95	60.00	+1.13	14.15	52.70	−0.41	11.65	57.18	165 38	34	41	42	25
Red Cross	+3 73	12.63	56.25	+1.91	9.00	58.25	−2.62	13.27	58.25	−1.49	15.09	53.70	+0.38	12.50	56.61	183.38	32	33	32	30
Red Wonder	−1.87	14.38	55 75	+3 94	10.30	62.50	+1.25	13.14	59.25	+1.16	17.80	56.20	+1.12	13.91	58.42	210 24	13	11	4	14
Rural New Yorker No. 6	+2.95	13.81	57.25	+2 20	8.79	58.75	−1.50	12.56	54.50	−2.41	17.09	50.00	+0.31	13.06	55.10	191.04	23	26	20	40
Sibley's New Golden	+1.30	14.38	57 25	+0.55	10.18	60.75	+4.21	14.20	59 75	+1.62	17.71	57.00	+1.92	14.12	58.69	220.19	25	4	3	9
Smith's Rust Proof	+2 70	13.88	56.50	−1 84	9.25	57.50	+2 17	12.79	58.25	+2.00	16.34	55.00	+1 26	13.07	56.81	198.64	22	21	19	28
Stanley	−0 66	12 75	56.25	−6.94	9.93	59.50	+6.26	12.40	58 50	+1 34	15.75	55.70	0.00	12.71	57.49	183.56	30	32	28	23
Turkish Red	−2 57	14.50	58.75	−4.53	9.93	60.25	+0.29	12 04	57.50	−5 37	15.78	50 00	−3 04	13.06	56.62	164.79	38	42	22	29
Valley	+1 49	13 50	57 75	+5.10	9.43	59.50	+2 09	12.92	59.75	+4.79	15 75	57.70	+3 37	12.90	58 67	212.39	6	9	26	10
Average	+1.49	13.53	57.04	+1.06	9.57	59.48	+0.81	12.61	57.84	+1.19	16.07	55.23	+1.14	12.94	59.70	195.80				
Velvet Chaff	Bu. per a.			Bu. per a.			Bu. per a.			Bu. per a.			Bu. per a.							
Av. all check plots	24.88	15.19	57.52	33.37	11.79	58.48	22.87	14.10	57.50	15.15	17.25	57.80	24.07	14.58	57.82	210.56	28	10	1	20
Av. of all varities	26.37	13.53	57.04	34.43	9.57	59.48	23.68	12.61	57.84	16.34	16.07	55.23	25.21	12.94	59.66	196.15				



Lebanon Lehigh Fulcaster Deitz



Fultzo-Mediterranean. Fultz. Red Wonder. Mealy.

It will be noted that while the variation in per cent of protein differs radically from season to season, yet varieties which are relatively high one season are relatively high all seasons. In other words, it is characteristic of some varieties to run uniformly higher in protein than others. Unfortunately many of the varieties testing highest in protein are not noted for conspicuously high yield. Of the 43 varieties considered, the 10 ranking highest in per cent of protein, in point of yield rank from 13th to 33rd. It should be observed, however, that they rank considerably higher in yield than the 10 varieties testing lowest in protein.

The problem of uniting high protein content with high yielding qualities is an interesting one to the plant breeder. Three methods of procedure suggest themselves: (1) The hybridization of high protein and high yielding varieties; (2) The selection of plants testing high in protein from varieties already excelling in yield; (3) The improvement of varieties uniformly high in protein content by systematic selection for high yield. Experience will have to determine the best method.

Another important quality in wheat is weight per bushel. While the table clearly shows that, as the seasons go, conditions which favor low yield and especially light weight per bushel uniformly result in high per cent of protein, yet it is evident that high protein follows light weight per bushel only as the latter is due to seasonal influences. It does not follow light weight per bushel as a variety characteristic.

The 10 varieties testing highest in protein rank from 1st to 27th in weight per bushel, while the ten varieties testing lowest rank from 22nd to 42nd in weight per bushel. Accordingly it would seem entirely reasonable to attempt to incorporate in one variety the qualities of high yield, high protein content and high weight per bushel.

It is a matter of no little interest to inquire into the causes of this variation in protein content from season to season. It should be noted that the variation is independent of varieties and of soil treatment. Taking the extremes as shown in Table III (see average of all varieties at bottom of table): 43 varieties had an average protein content of 9.57 per cent in the year 1903, and an average of 16.07 per cent in 1901, treatment as regards fertilization being practically the same for each crop.

This wide variation cannot be ascribed to anything except seasonal influences. In seasons in which wheat is found to be shrunken and of light weight the protein content is *relatively* high.

It seems to be quite clear that this high *per cent* of protein is due to a shortage in the starch content. In brief, the kernel is normal or nearly so, in its bran, aleurone layer and germ, but short in endosperm.

In Table IV are shown data relative to rainfall, temperature, date of harvest, yield and quality of wheat for the four crops in question.

TABLE IV:—RAINFALL AND TEMPERATURE IN RELATION TO WHEAT YIELDS, WEIGHT PER BUSHEL AND PER CENT OF PROTEIN.

Year.	Mean av. temperature, May.	Mean av. temperature, June.	Mean av. temperature, 10 days, June 25 to July 4	Rainfall for June.	Date of harvest.	Average of 43 Varieties.			
						Yield per acre.	Protein	Weight per bushel.	Protein per acre.
	Degrees.	Degrees.	Degrees.	Inches		Bushels	Per ct.	Pounds.	Pounds.
1901	57.9	69.1	78 6	4.82	July 10	16.61	16.07	55.23	160.15
1902	61.2	65.6	65.2	5.55	July 10	23.78	12.61	57.84	179.92
1903	62.3	63.0	71.2	3.69	July 3	34.17	9.57	59.48	196.20
1904	59.3	67.0	68.3	1.67	July 17	26.49	13.53	57.04	215.05

It will take data for more seasons than we are now able to put together to justify the drawing of definite conclusions. From facts given in the above table it would seem that the mean average temperature for the month preceding wheat harvest, the month of June, has much to do with yield, weight per bushel and per cent of protein.

Arrange these four seasons in the order of their June temperature and you have them arranged in the order of their rank in per cent of protein and weight per bushel. The higher the temperature the higher the per cent of protein and the lower the weight per bushel. This is in accord with observations made by Director Deherain of the Experiment Station of Grignon, France, as quoted by Dr. Wiley in the Yearbook of the U. S. Department of Agriculture for 1901, page 308.

As Dr. Wiley points out, and as has already been observed, the apparent increase in protein production is not real. The total yield of protein is less in pounds per acre the year of the highest per cent of protein (1901) than it is in 1903, the year the per cent of protein is lowest, being 160 pounds per acre the former year and 196 pounds the latter.

When, as in the year 1901, a hot June is preceded by a cool May and, as well, when the last few days preceding harvest are increasingly hot, conditions are most favorable for the shriveling of wheat. Other complications enter in, such as rust, the work of the Hessian fly, and the midge, all of which tend to produce shriveling.

1 2 3 4

Nos. 1 and 3 grown from large grains. Nos. 2 and 4 grown from small grains.

TABLE V.—THE RELATION OF FERTILITY OF SOIL TO PROTEM CONTENT AND WEIGHT PER BUSHEL.—5-CROP ROTATION.

Plot	Fertilizing materials applied during each 5-crop rotation.	Per cent of protein found in grain in the years:—					Average per cent protein	10 year average yield per acre.		Average weight per measured bushel, lbs.	Pounds protein per acre
		1897	1898	1899	1902	1903		Grain, bushels per acre	Straw, pounds per acre		
1	None.	12.00		12.69	15 58		13.42	8 91	921	56.07	71.74
2	Ac d phosphate .....320 lbs	11.12	11 87	13.06	12.45	9 59	11.60	15.51	1,586	59 37	107.95
3	Potiassium chloride.....260 lbs	12.44	11.00	12.69	15.14	10.78	12.41	10.40	1,070	56.96	77.44
4	No ne .	12.00	8.87		15.31	10 88	11.76	9.27	945	56 21	65.61
5	S dium nitrate.....480 lbs	12.44	11.43	14.37	16.16	11.37	13.15	11.08	1,173	55.87	87.42
6	A°id phosphate .....320 lbs Scdium nitrate.....480 lbs	11.56	11.43	13.06	13.34	9.98	11.87	20.65	2,142	59.65	147.07
7	Noone.	12.00	11.43		15.23	10.56	12.30	9.24	966	57.34	68.19
8	Acid phosphate.....320 lbs Potassium chloride.....260 lbs	11.12	11.00	12.69	10.57	9.75	11.02	17.49	1,679	59.74	115.64
9	Potassi um chloride.....260 lbs Sodium nitrate.....480 lbs	13.68	11 43	13.06	16.00	10.55	12.94	11.60	1,187	56.25	90.06
10	None.	12.87	11.00	13.06	13.97	10.31	12.24	9.21	911	55.85	67.64
11	Acid phosphate .....320 lbs Potassium chloride.....260 lbs Sodium nitrate.....480 lbs	11.56	11.00	12.69	12.27	9.50	11.40	24.00	2,516	59.68	164.16
12	Acid phosphate .....320 lbs Potassium chloride.....260 lbs Sodium nitrate.....720 lbs	12.00	11.43	13.06	12.61	9.78	11.77	25.16	2,567	59.18	177.68
13	None.		11.43		14.44	10 22	12.03	9 26	909	55.85	66.84

In studying the effect of the application of different fertilizers upon the protein content of wheat (Table V) it will be noted that the plots without fertilizers and those without phosphorus give a light yield per acre of wheat which tests low in weight per bushel and high in per cent of protein.

Plots which get an application of phosphorus (in the form of acid phosphate) alone, or in combination with other fertilizing materials, give a greatly increased yield in bushels per acre of a wheat which tests considerably higher in weight per bushel but is lower in per cent of protein. In other words, fertilizers affect the per cent of protein as they affect the weight per bushel—the plumpness of the kernel. As before, it is more a matter of high and low starch than of protein. Phosphorus gives the large yield, the plump wheat, the high starch content and *relatively* low protein. In the absence of phosphorus we have light yield, incomplete filling out of starch cells and relatively high protein. The 5 plots above getting phosphorus average 11.53 per cent protein. The balance of the plots, both with and without fertilizers, average 12.53 per cent protein. The latter are high in protein *because* they are low in starch. They are low in starch because of incomplete development.

So far as affecting the *per cent* of protein with fertilizers is concerned it would seem that it cannot be fed into the wheat through the soil. The protein product *per acre* can be increased very materially, but only by increasing the yield in bushels per acre.

THE VERDICT OF SOME OHIO MILLERS AND THE COLUMBUS LABORATORIES OF CHICAGO UPON THE MILLING AND BAKING QUALITIES OF SOME OF THE DIFFERENT VARIETIES OF WHEAT UNDER DICUSSION.

In July of 1904 the following letter was addressed to some 75 millers, well scattered over the state:

"The Ohio Experiment Station desires to get the opinion of representative millers of our State as to the best milling winter wheats grown in their respective localities. Accordingly it asks you to rank the following varieties in the order of their merit, providing you have had experience in milling them: Dawson's Golden Chaff, Democrat, Fulcaster, Fultz, Mealy, Mediterranean, Poole, Turkish Red, Valley, Velvet Chaff.

You are at liberty to add to the list any other varieties with which you are familiar.

Do you discriminate in price against any of these varieties?"

46 replies were received to this communication with the following result:

26 millers pronounced Mediterranean wheat 1st in quality.
10 " " Fulcaster " " " "
10 " " Fultz " " " "
5 " " Poole " " " "
3 " " Mealy " " " "
2 " " Democrat " " " "
2 " " Velvet Chaff " " " "
1 each the Rudy, Dawson's Golden Chaff, Harvest Queen and Turkish Red wheat 1st in quality.

Poole was ranked 2nd by 19 millers.
Mediterranean " " " 7 "
Fulcaster " " " 5 "
Fultz " " " 4 "
Democrat " " " 2 "

Nigger, Lancaster, Rudy, Mealy, Velvet Chaff, each 2nd by 1 miller.

7 millers discriminated against the Mealy wheat, 1 against Dawson's Golden Chaff and 1 against the Turkish Red.

In July of the same year 34 different samples of wheat were sent to the Columbus Laboratories of Chicago, Ill., for a milling and baking test.

These samples were sent under number and represented 31 varieties of wheat. 7 of these samples were of the harvest of 1901, 22 of the harvest of 1902, and 5 of the harvest of 1903.

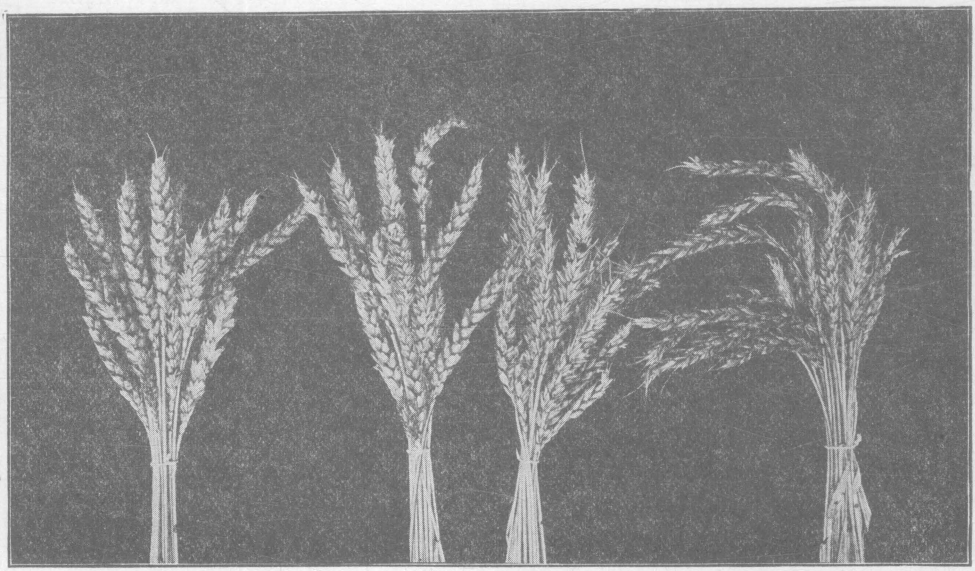
After having made a complete test as to per cent of yield of flour, per cent of ash, absorption, color, number of loaves per barrel, size of loaf, and quality of gluten, the Columbus Laboratories were asked to name the ten best samples in the order of their rank from the standpoint of the miller and baker. This they did under number with the following result:

Rank.	VARIETY.	Year grown.
1	Democrat	1901
2	Mealy	1901
3	Early Ripe	1901
4	Currell's Prolific	1902
5	Deitz	1902
6	Lebanon	1902
7	Velvet Chaff	1901
8	Red Wonder	1902
9	Poole	1901
10	Early Red Clawson	1902

It is probable that much of the objection made against Mealy wheat by some millers is due to the fact, as some of them have pointed out in their replies to the above communication, that this variety needs different manipulation in milling from many other varieties. That it is a good milling wheat when properly handled would seem evident. It is possible, however, that many millers

5 6 7 8

Nos. 5 and 7 grown from large grains. Nos. 6 and 8 grown from small grains.



9 10 11 12

Nos. 9 and 11 grown from large grains. Nos. 10 and 12 grown from small grains.

cannot handle it with as great success as they can varieties with which they have had more experience, and also possible that it cannot be milled as successfully when mixed with softer wheats as when milled alone.

THE BEST VARIETY OF WINTER WHEAT FOR OHIO.

The Station would not undertake to say of any variety that, so far as yield of grain is concerned, it will prove the most satisfactory of all those it has tested for all localities, or, indeed for any given locality. Some varieties are better adapted to certain soils than others. A variety will give a better comparative yield on a given soil in certain seasons than it will in others.

Of the sixty or more varieties tested each year for the last thirteen years no one variety has outyielded all others more than *two* years out of the thirteen and no variety has outyielded all others two years in succession. In the harvest of 1905 the Democrat wheat heads the list; in 1904, the Nigger wheat; in 1903, the Extra Early Windsor; in 1902, the Stanley; in 1901, the Gypsy; in 1900, the Early Ripe; in 1899, the Red Russian; in 1898, the Mediterranean; in 1897, the Red Russian; in 1896, the Gold Coin; in 1895, the Gypsy; in 1894, the Mealy; in 1893, the Rudy.

Some of these varieties—the Stanley, the Gold Coin and the Rudy for instance—forged to the front *one season*, but for the most part have lagged well in the rear.

The necessity for long time tests, conducted upon a number of different types of soil, would seem to be plainly indicated.

The Station is conducting experiments upon its three test farms, located at Strongsville, Cuyahoga county, Germantown, Montgomery county and Carpenter, Meigs county, as well as co-operating with several hundred farmers of the state through its department of co-operative experiments, in charge of Mr. L. H. Goddard, and will have in a few years valuable data to publish from these several sources. The data given in this bulletin are based upon work done at the main Station, upon a soil that is representative of a considerable portion of the state.

Using these data, as recorded in the preceding pages, the several varieties reported upon are ranked as to their comparative value from the standpoint of the wheat grower.

That which interests the latter in a variety of wheat is: 1st yield per acre; 2nd, weight per bushel; 3rd, milling and baking quality. The protein content, in connection with weight per bushel,

is a fairly accurate indication of the third item and will be used in grading or scoring the varieties under consideration for this quality.

There are other qualities that suggest themselves as of great importance in determining the value of a variety of wheat, as rust resistance and stiffnesss of straw, which are deserving of great consideration in the production of new varieties, or in the improvement of old varieties, but which do not especially concern us in ranking these varieties for which we have a comparative yield record extending over a dozen years. Any weakness in either of these directions will have become apparent in the yield of the variety.

It remains to be determined how many points shall be given each of the items mentioned above. The following score card is proposed, tentatively, as perhaps serviceable for present purposes:

1—Yield per acre—60 points.
2—Weight per bushel—25 points.
3 -Protein content—15 points.

Scored in accordance with the above card, the 40 varieties for which we have the necessary data are marked as follows:

TABLE VI.—COMPARATIVE RANK OF 40 VARIETIES OF WINTER WHEAT SCORED AS TO YIELD, WEIGHT PER BUSHEL AND PROTEIN CONTENT.

VARIETY.	Yield.	Weight per bushel.	Protein content.	Total score.	Rank.
Gypsy	60 00	24 10	10.62	94.72	1
Early Ripe	58 74	23.25	12.20	94 19	2
Nigger	57 74	23.68	11.96	93.38	3
Poole	57 94	22 80	11.66	92.40	4
Mealy	59.67	21.25	11.04	91.96	5
Currell's Prolific	54.40	23.82	12 32	90 54	6
Valley	54 54	23 87	11.64	90 05	7
Red Wonder	51 57	24.28	13.66	89 51	8
Democrat	52 60	23 64	12.40	88.64	9
Fulcaster	50.00	24.17	13.56	87.73	10
Nixon	52.17	23 66	11 84	87 67	11
Deitz	50 14	23.85	13.02	87.01	12
New Monarch	52 34	22.50	12.14	86.98	13
Lebanon	49 84	23.67	13 46	86 97	14
Harvest King	53 00	22 79	11.18	86.97	15
Lehigh	48.94	23.32	14 34	86.60	16
Velvet Chaff	47.37	23 20	15.00	85.54	17
Sibley's New Golden	48 04	23 17	14.08	85.29	18
Hickman	48.34	24 29	12.36	84 99	19
Fultz	48.77	23 39	12.56	84 72	20
Dawson's Golden Chaff	53 07	21 74	9.00	83 81	21
Smith's Rust Proof	48.77	21.75	11.98	82 50	22
New Columbia	46.60	21 71	13.10	81 41	23
Bearded Winter Fife	48.87	21.85	10.02	80 74	24
' ural New Yorker No. 6	48 54	20.17	11.96	80.67	25
International No. 6	50.40	20.18	10 02	80 60	26
Fultzo-Mediteranean	44 60	22.70	13.04	80 34	27
Harvest Queen	49 60	20.74	9 58	79 92	28
American Bronze	47 87	21 71	10.34	79.92	29
Stanley	46 47	21.53	11.26	79 26	30
Early Red Clawson	45 17	22.49	11.40	79 06	31
Red Cross	46 24	21 91	10 84	78.99	32
Giant Square Head	47.57	18.68	12.06	78.31	33
Gold Coin	46.34	20.60	9 96	76.90	34
Diamond Grit	42 84	22.92	9.74	75 50	35
Pride of Genesee	43 20	22.74	9.14	75 08	36
Turkish Red	40.34	22.29	11.96	74.59	37
Long Amber	42.17	22 13	10.08	74.38	38
Jones Square Head	42.30	20.78	11.18	74.26	39
Early Arcadian	37.34	20.37	10.16	67.87	40

TABLE VII.—THICK AND THIN SEEDING, YIELD IN BUSHELS PER ACRE.

	Pecks of Seed per acre.							
	3	4	5	6	7	8	9	10
Year	VALLEY WHEAT.							
1894	5.00	6.20	8.30	6 80	8.20	10 85	10.50	12.50
1895	6.20	6.87	7.29	6 78	8.04	9.49	.....	.....
1896	6.49	7 95	8.83	7 33	8.00	8.66	.....	.....
1897	18.58	17.79	18.03	20 33	19.41	20.25	20.08	18 58
1898	12.91	12 33	15.41	17.04	17.75	21.59	21.54	22.79
1899	23.16	19 62	21.29	23.33	22 76	23 24	26.16	24.33
1900	7.83	7.13	7.20	8.08	10.58	10.33	9 56	11.41
1901	21.12	20.54	21.83	21.96	21.91	22.75	21.00	20.91
Average. .	12.66	12.30	13.52	13.96	14.58	15.90	.....	.....
	RUDY WHEAT.							
1895	2.33	3.33	3.74	5.12	4 50	5.12	.....	5.2 5
1896	6.33	6.49	5 03	7.25	8.83	10.16	10.33	10.66
1897	16.95	22.24	21.87	22.53	24.24	26.37	24.41	29.33
Average...	8.53	10.69	10.21	11.63	12.86	13.88	.....	15.08
	POOLE WHEAT.							
1898	16.33	18.54	20.50	20.83	19.87	21.62	21.04	18.54
1899	15.83	21.16	20.16	22 83	21.58	26.08	28.83	27.33
1900	12 42	10.17	12 96	11.91	11.41	12.50	13.41	10.58
Average...	14.86	16.62	17.87	18.52	17.62	22.07	21.09	18.82
	FULTZ WHEAT.							
1901	17.29	16.12	19 29	19.88	22.33	20.83	21.58	22.00
1902	17.00	20 25	17.66	23.58	23.00	24.33	25.66	29.33
1903	25.29	29.58	32.60	35.17	35.91	35 00	38.58	43.33
1904	10.01	12.08	13 58	14.56	16 04	16·95	16.83	18.58
Average...	17.40	19.51	20.78	23.30	24.32	24 28	25.66	28.06
	MEALY WHEAT.							
1903	27.21	32.54	35.46	38.33	36 67	35.12	35.46	39.50
1904	9.16	12.66	15.50	16 50	17.25	1 66	15.21	15.33
Average...	18.18	22.60	25.48	27.41	26.96	25 89	25.33	27.41
Combined average	15.43	16.79	18.04	19.46	19 86	20.85	21.19	22.06
	THICK AND THIN SEEDING. Weight per bushel before screening.							
Combined average	58.38	58.50	58.17	58.71	58.67	58.70	58.92	58.83

THICK AND THIN SEEDING.

Table VII gives the results of a series of experiments testing different amounts of seed per acre, ranging from 3 to 10 pecks. This work extends over eleven years and includes a great variety of seasons. Five different varieties of wheat have been used in this work, including those having small kernels like the Mealy and large kerneled varieties like the Rudy.

The combined average yields from the different rates of seeding, which include 17 distinct tests (omitting 3 incomplete

tests) show a gradual increase in yield from 15.43 bushels per acre with a seeding of 3 pecks, up to 22.06 bushels per acre with the use of 10 pecks of seed.

Nine of the 20 tests 10 pecks led in yield;
Three " " " " 9 " " " "
Three " " " " 8 " " " "
Three " " " " 7 " " " "
One " " " " 6 " " " "
One " " " " 5 " " " "

There has been but very little difference in the weight per bushel of the wheat grown from the different rates of seeding.

EARLY AND LATE SEEDING.

TABLE VIII.—EARLY AND LATE SEEDING OF WHEAT.

YEAR AND YIELD IN BUSHELS PER ACRE.

DATE OF SEEDING.	1899	1900	1901	1902	1903	1904	6-year average.	*4-year average.
	Valley.	Poole.	Fultz.	Valley.	Mealy.	Mealy.		
Aug. 31—Sept. 1	18 00		9.83	25.00	30.66	17.33	20.16	22.75
Sept. 7—8	18.33		5.50	26.80	28.00	19.92	19.17	23.19
Sept. 14—15	25 50		5.66	25.50	34 33	23.92	22.98	27.31
Sept. 21—22	23.50	13.75	2.00	28.50	36 83	24.33	21 48	28.79
Sept. 28—29	22.83	16.75	14.00	25.50	30 66	24.33	22.34	25.83
Oct. 5—6	21.50	15.66	19.50	25.50	26.91	19.33	21.40	23.31
Oct. 12—13	19.33	10.41	19.83	22 10	21.00	19.87	18.76	20.75
Oct. 19—20	11.16	8.00	11.66	15.50	15.25			10.60
Oct 26—27			11.66	9.33	12.41			8.35

*Cutting out two crops 1900-1901 nearly ruined by Hessian fly.

Table VIII gives the yield of wheat secured from seedings made at different dates for the years 1899–1904 inclusive. Two of the six years the Hessian fly nearly, or quite ruined two or three of the seedings made in September, and in 1904 the last two seedings of October made so slight a growth before winter set in that they were winter killed to a finish. In normal seasons, September 20 to 22 has proven the most satisfactory date for seeding in this latitude, with September 15 a close second.

WHEAT IMPROVEMENT.

THE FANNING MILL METHOD.

The late Prof. Hickman reported in Bulletin 129 experiments comparing different grades of seed wheat as separated by the fanning mill.

Three grades were used: First grade, the large grains; second grade the best of the grains passing through the sieve in screening out the first grade; third, unscreened wheat as it came from the thresher. These tests extended over nine years and were conducted with three different varieties of wheat for the entire period. After the first year the seed for each grade was selected from wheat grown from the same grade the year previous.

The average yield per acre and weight per bushel for the nine years are as follows:

TABLE IX.

VARIETY.	Average yield per acre in bushels.			Average weight per bushel.		
	First grade.	Second grade.	Third grade.	First grade.	Second grade.	Third grade.
Velvet Chaff	15 48	16.06	16.03	57.8	58 3	58.1
Deitz	17.16	17.64	16.69	57.2	57 9	58.1
Hicks	16.11	15.82	16.06	57.7	58.0	57.4
Average	16.25	16.50	16.26	57.6	58.1	57.9

Prof. Hickman says: "The average results as shown do not furnish data to demonstrate the theory usually accepted. The only conclusion to be drawn from the above is that the quality (size and possibly weight) of the seed does not influence materially the quantity and quality of the crop, or else the variation in the quality of the seed has not been sufficiently marked."

Two years' further work was put out by Prof. Hickman, one of which was harvested by the writer, which confirms the preceding.

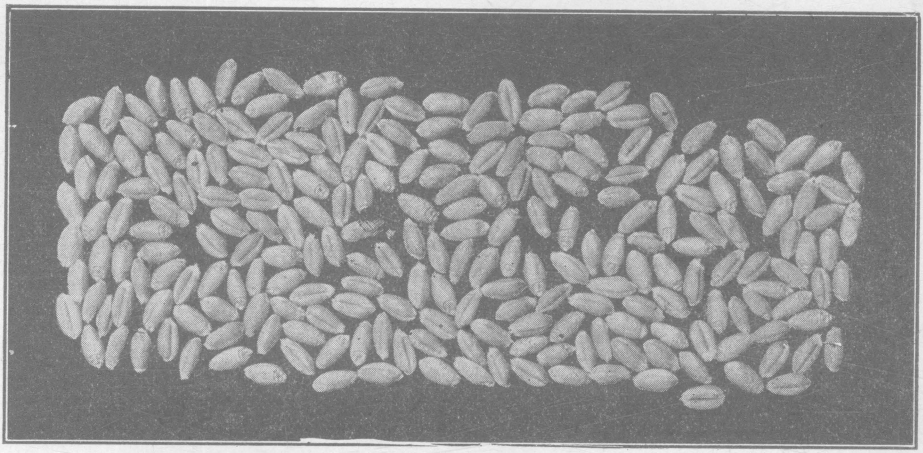
In view of the results secured by some other stations from the use of large and heavy grains, and acting upon the suggestion that possibly there had not been enough difference in the seed used, the writer took two bushels of Velvet Chaff wheat, put it through a modern fanning mill a number of times, separating it into three quite distinct grades. Photo engravings of these grades are included in this bulletin, but fail in part to show the differences apparent upon actual examination. Owing to the much smaller size of the grains of the inferior seed a duplicate series was planted in which the rate of seeding was varied to conform to the size of the grains. This had not been provided for in Prof. Hickman's work.

The following table gives the plan and the results of the, test the size of plots used being one-tenth acre:

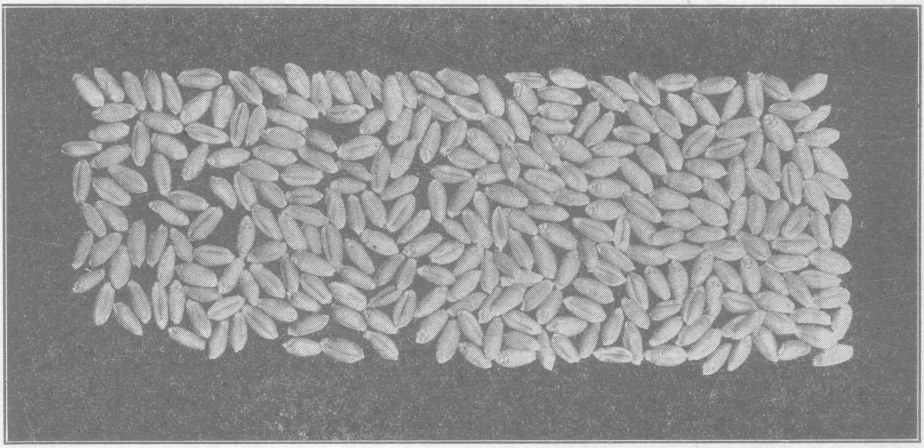
TABLE X.—SIZE AND WEIGHT OF SEED AS AFFECTING CROP.

HARVEST OF 1904.

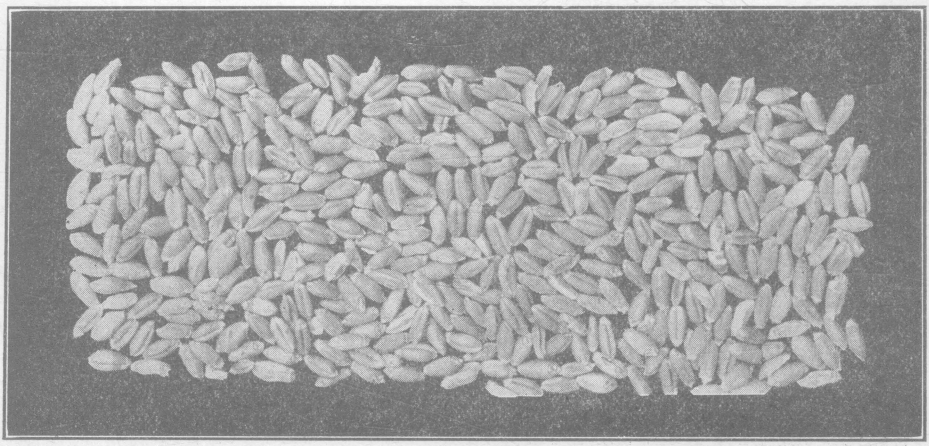
Grade of Seed.	Weight per bushel. Lbs.	Number of kernels per ounce.	Pecks of seed per acre.	Yield in bushels per acre.	Weight per bushel. Before Screening.	Weight per bushel. After Screening.	Straw per acre.	Straw per bushel.
1st	61.50	672	8	24 50	58 00	60 25	2,280	93
2nd	60.75	810	8	26 46	57 50	60 50	2.712	102
3rd	57.00	1134	8	24 16	58.75	61 25	2 350	97
1st	61.50	672	8	23 00	59 75	60.75	1,970	85
2nd	60.75	810	6.5	24.04	57 75	61.25	2.277	94
3rd	57.00	1134	5	24.50	57.00	60 25	2,930	119
1st	61.50	672	8	24.71	59 00	60.75	2,567	103



672 Grains per ounce. FIRST GRADE. Weight, 61.50 pounds per bushel.



810 Grains per ounce SECOND GRADE. Weight, 60.75 pounds per bushel.



1,134 Grains per ounce. THIRD GRADE. Weight, 57.00 pounds per bushel.

The first grade seed averages 24.07 bushels per acre.
The second " " " 25.25 " " "
The third " " " 24.33 " " "

In weight per bushel before screening the first grade exceeds the third by 1.04 pounds.

This work was repeated the following year as above, seven plots being seeded with grades having grains of similar size and weight, and in each instance the seed used was selected from wheat grown from the same grade the year previous.

The harvest of 1905 gives the following results:

The first grade averages 21.22 bushels per acre
The second " " 19.91 " " "
The third " " 19.21 " " "

Weight per bushel before screening; First grade, 56.92 lbs; second, 56.62 lbs; third, 57.38 lbs.

It should be recorded that the fall of 1904 was perhaps the most unfavorable to the growth of wheat at the Station of any in recent years. The rainfall from Sept. 22 to Nov. 30 was 1.87 inches. The next lightest rainfall between these dates for the ten year period is 4.59 inches.

HAND SELECTION OF LARGE VS. SMALL GRAINS.

In the fall of 1904 twelve 6½ inch pots were planted with hand-sorted seed of large and small grains. The pots were planted in pairs, Nos. 1 and 2 with large and small grains respectively, selected from the *same plant*. Nos. 3 and 4 with large and small grains from another plant, and so on, the odd numbers being planted with large grains and the even with small grains.

Eight grains were planted in each pot, which later was thinned to six plants. The average weight of the seed planted in each of Nos. 1, 3, 5, 7, 9, 11 was 0.3907 grams; of that planted in Nos. 2, 4, 6, 8, 10, 12, 0.1837 grams.

In four days after planting most of the plants had appeared, no difference being shown as to rapidity of germination of the two grades. The plants from the large grains, however, rapidly grew away from those grown from small grains and by two weeks were fully twice as large. This difference in size gradually disappeared, and when harvested the plants from the small grains appeared to be fully equal, and in some instances superior to those grown from the large grains. (See illustration page 47-51). The average weight of threshed grain from the large grains was 13.21 grams per pot; from the small grains 15.68 grams per pot.

Similar hand sorted seed was planted in four-feet-square plots in the field the same season. The very unfavorable weather practically destroyed the plots planted from small grains, while those planted from large grains made one-fourth of a crop.

The selection of grains, whether by means of fanning mill or by hand, does not seem to promise anything in the way of permanent improvement in wheat. In normal seasons there is little if any temporary gain. In extremely unfavorable seasons the extra amount of food furnished the young plant by the large kernel places it in a position to withstand greater hardship and is accordingly an advantage to it. One seeking to permanently improve wheat by selection will have to look elsewhere than to the size of the kernel.

SELECTION OF LARGE HEADS.

In 1903 experiments were begun in which field selections of large heads were compared with small heads. The large and small selections made from the Mealy variety are shown herewith. The choice heads of Mealy had from 75 to 89 grains each, weighing 3.4616 grams. The inferior heads had 18 grains each and weighed 0.6405 grams.

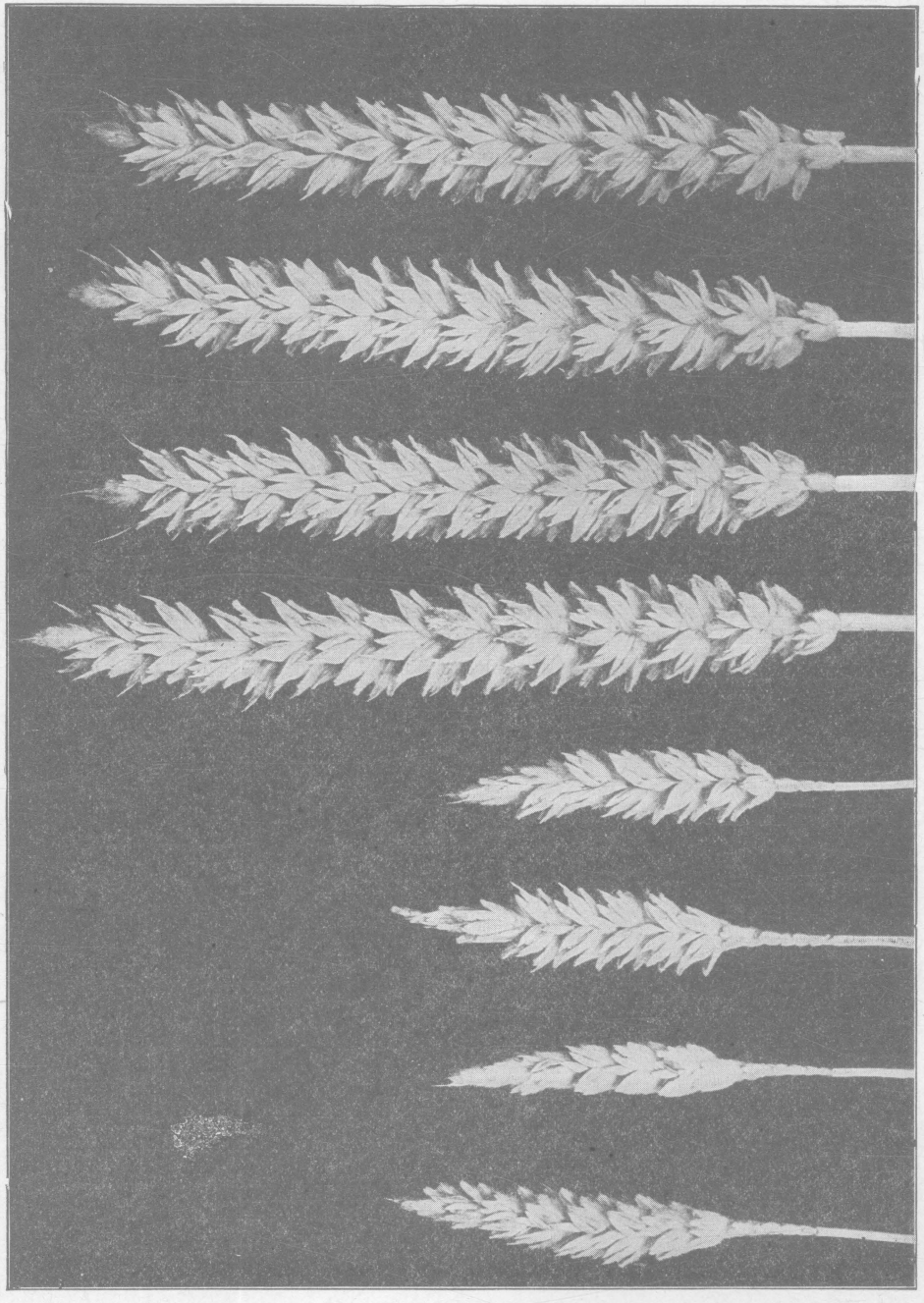
Similar selections of Poole wheat were made, the large heads having 42 grains weighing 1.8355 grams and the small heads having 19 grains weighing 0.7227 grams.

Equal numbers of the best plants were harvested from each hand plot.

The average weight of grain per plant grown from the large heads of Mealy was 8 grams; from the small heads of Mealy 9.25 grams; from the large heads of Poole 4.34 grams, from the small heads of Poole 3.67 grams.

These plots suffered greatly from winter killing, the Poole plots more than the Mealy.

This report is not given because it is thought to be conclusive, but simply to call attention to what the writer believes to be a fact, that improvment must come, if at all, from the selection of the plant as a whole rather than of any of its parts. The abnormally large head is valueless for two reasons: 1. It owes its great size to environment which it would be impracticable to reproduce. 2. It usually possesses not the high degree of excellence which it seems to to represent but the *average* excellence of a plant composed of other parts.



Selected Mealy (Superior)

Selected Mealy (Inferior)

In its effort to perpetuate itself the wheat plant throws out more shoots than it can bring to complete maturity. Some fail to develop any seed; others produce short heads, with many poor grains. These small and in other ways inferior grains, found in good and poor heads alike, partake of the nature of the plant of which they are a part. The plant is *one* and *any* of its seeds *under favorable conditions* will reproduce the plant equally well.

This explains the facts reported in Table X. A certain number of plants are represented in a sack of wheat caught from the thresher. It is separated into three grades according to the size of kernel and put in three sacks, but the same individual plants are represented in each sack. One part of a plant is matched against another part. And the result shows that under normal conditions these parts do not differ very much.

THE SELECTION OF PLANTS.

The concern of the plant breeder who would improve the wheat crop is therefore with the plant as a whole. That there is wide variation in the productivity of individual wheat plants is very apparent. Much of this variation is due to environment. Some of it to heredity. The problem is to separate the transitory and accidental from the hereditary and permanent.

Animal breeders have an advantage in one particular at least in that they can absolutely control the environment. If one dairy cow of a herd produces twenty-five per cent more fat than any other it can be known with certainty that this production is due to something inherent in the cow. That these and other qualities may be perpetuated in the offspring the official records of the modern dairy cow and the feats of the American trotting horse bear abundant witness. Our animal breeders have demonstrated the possibility of bringing the average of their herds up to the level of the best animals of a few generations ago.

The plant breeder has yet to demonstrate his ability to bring all the wheat plants of a field up to the level of the production of the best individuals of today. That is the problem which confronts him.

The writer has work in progress by which it is hoped these best plants may be separated from the common multitude.

The plan in brief is this:

FIRST YEAR'S WORK: Field selection of seed from the best two or three varieties as the plants are beginning to ripen. It is not practical to distinguish plants (stools) as a whole in the thickly planted drill row, but especial care is taken to select heads where

the plants are normally thick. Good-sized heads are desirable, but excessive length is to be avoided, especially if it be due to wide space between the spikelets, or a thin stand of plants. Comparative earliness and freedom from rust go together and are both very important, as is stiffness of straw.

From these selections 5,000 to 10,000 grains are planted, a grain in a place four inches apart each way, in convenient foundation beds. All vacancies caused by failure of seed to germinate are replanted.

Outside rows of plants and those adjoining vacant spaces are discarded at harvest.

50 to 100 of the best plants are harvested and 25 of the heaviest yielding plants, if satisfactory in other ways, go into the second year's breeding work.

SECOND YEAR'S WORK: About 2500 grains are planted from the 25 plants saved from the first year's breeding plots, the grains from each indvidual plant being planted together. Between these individual plants are alternated an equal number of rows from choice field selections of the same variety, made as in the first year's work. The latter serve as a check upon the first year's selections. No vacant spaces are left between these plots or rows. All are planted solid.

As in the first year's work, the best 25 plants of the entire lot are saved.

THIRD YEAR'S WORK: About 100 grains are planted from each of the 25 plants saved from the second year's breeding work, in as many centgener plots. Every plant in each of these plots is harvested, thus securing the total centgener plot yield, and the *average* yield per plant. The 15 giving the lowest average yield per plant are dropped. The best 10 are perpetuated by selecting a composite sample from portions of several of the best plants of each.

FOURTH YEAR'S WORK: (a) The best 10 centgener plots of the previous year are given a second year's record, securing the average yield per plant as before and selections for perpetuating the strains made as in the third year's work.

(b) 5000 more plants are started from new field selections and the work carried on as in the first year's work.

FIFTH YEAR'S WORK: (a) A third and last centgener record is given the original 10 plants and the 3 standing highest in average yield per plant in all three centgener tests are saved for multiplication and further testing as new varieties. The others are dropped.

(b) A duplication of the 2nd year's breeding work, using the best 25 plants of the 4th year's work (b), and new field selections, saving as before the best 25 plants of the entire lot.

SIXTH YEAR'S WORK: New centgener plots are started for a three year's test as in the 3rd year's work, using the 25 plants saved from 5th year's work (b).

This plan, in operation at the Station, is based in large part upon the work of Prof. Willet M. Hays, U. S. Assistant Secretary of Agriculture.

SUMMARY.

1 Yield of grain alone being considered, the best ten varieties, in the order of their rank are: Gypsy, Mealy, Early Ripe, Poole, Nigger, Perfection, Mediterranean, Valley, Currell's Prolific and Dawson's Golden Chaff.

2 Weight per bushel being considered, the ten varieties testing highest are: Hickman, Red Wonder, Fulcaster, Gypsy, Valley, Deitz, Currell's Prolific, Perfection, Nigger and Lebanon.

3 The ten varieties ranking highest in percent of protein are: Velvet Chaff, Lehigh, Sibley's New Golden, Red Wonder, Lebanon, New Columbia, Fultzo-Mediterranean, Deitz and Buda Pesth.

4 Climatic conditions have much to do with the protein content of wheat. High temperature for the month preceding wheat harvest, results quite uniformly in decreasing the yield and weight per bushel but in increasing the *per cent* of protein. The latter is due to a shortage in starch content rather than any actual increase of protein.

5 Anything which tends to interfere with the normal development of the kernel, as rust, Hessian fly, or midge, tends to increase the percentage composition of the protein.

6 High protein resulting from seasonal influences or insect depredations is not desirable, as it is to be found more largely in the bran and other waste products than in the flour.

7 High protein as found in normally plump wheat is desirable. As a variety characteristic it is to be sought for.

8 Ranking the several varieties as to yield, weight per bushel and protein content, giving 60 points to yield, 25 points to weight per bushel and 15 points to protein content, the ten varieties scoring highest are: Gypsy, Early Ripe, Nigger, Poole, Mealy,

Currell's Prolific, Valley, Red Wonder, Democrat and Fulcaster. It is believed that the first four varieties of this list will prove quite generally satisfactory over the State. While the Mealy does very well upon rather thin upland it is quite disappointing upon the richer soils and especially the bottom lands of the State. Strong in yield it has a greater tendency to shrivel than many varieties.

9 Experiments in thick and thin seeding, covering eleven years' work, indicate that 8 to 10 pecks of seed per acre will give better results than a less amount of seed upon the somewhat worn lands of the State. At the Germantown test farm 8 pecks have given the largest yield.

10 In normal seasons, September 20 to 22 has proven the most satisfactory date for seeding in the latitude of Wooster, with September 15 next highest in yield.

11 Experiments extending over a series of 13 years have failed to show *on the average* any gain from the use of seed from which the small and light grains have been removed by use of the fanning mill, although three seasons out of the thirteen the first grade gave largest yields.

12 In view of the possibility of an unfavorable season and of the fact that a more uniform seeding can be secured by removing the shrunken, broken and extremely small grains, the Station would advise doing this, but would not hold out any hope that mere grading of the seed will produce a permanent improvement in wheat or any marked temporary advantage, one season with another.

13 The selection of large, as compared with small heads does not promise much in the way of improvement.

14 Permanent improvement in wheat must be based upon the selection of plants as a whole, rather than upon parts of plants. Excellence due to hereditary influences must be distinguished from excellence due to environment.

15 Methods of wheat breeding by selection are given on preceeding pages.

THE SALE OF SEED WHEAT.

The Experiment Station has discontinued the sale of seed wheat, for two reasons: (1) because it is found to be practically impossible, in passing many varieties through the same machinery, to avoid a slight admixture, and (2) because it is believed that the Station can better serve the agriculture of the State as a whole, by using the small quantities of seed produced on its tenth-acre plots in the extension of its tests over the various soils of the State, through the medium of careful cooperative tests made under the supervision of its Department of Cooperative Experiments. Circulars explaining the conditions under which seed wheat will be furnished for such tests will be furnished on application.

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